(12) UK Patent Application (19) GB (11) 2 336 493 (13) A

(43) Date of A Publication 20.10.1999

(21) Application No 9904155.0

(22) Date of Filing 23.02.1999

(30) Priority Data
(31) 19811550 (32) 18.03.1998 (33) DE

(51) INT CL[6]
H03B 21/02, G01S 7/491 // G01S 17/36

(52) UK CL (Edition Q)
H3R RMA
H4D DLRE D747 D749 D773 D783
U1S S2138

(56) Documents Cited
GB 2128048 A GB 2039441 A GB 1420271 A
GB 1348221 A GB 1264770 A US 5107124 A
US 4959654 A

(58) Field of Search
UK CL (Edition Q) H3R RMA
INT CL[6] H03B 21/02
Online: EPODOC; JAPIO; WPI

(71) Applicant(s)
Robert Bosch GmbH
(Incorporated in the Federal Republic of Germany)
Wernerstrasse 1, Stuttgart-Feuerbach, D-70442
Stuttgart, Federal Republic of Germany

(72) Inventor(s)
Dierk Schmidt
Joerg Stierle
Peter Wolf
Gunter Flinspach

(74) Agent and/or Address for Service
A A Thornton & Co
Northumberland House, 303-306 High Holborn,
LONDON, WC1V 7LE, United Kingdom

(54) Abstract Title
Circuit arrangement for producing frequency signals

(57) In a circuit arrangement for generating at least two signals of different frequencies at least one pair of frequencies having closely adjacent frequencies f_1 and f_1', f_2 and f_2', f_3 and f_3' are derived from a frequency oscillator having a fundamental pulse f_0, 52. The circuit may be used to generate modulation frequencies of laser signals 16 for a distance measuring instrument 10. A trigger signal f_5 from a microprocessor 50 is used to generate the different adjacent frequencies. At least one frequency is generated by filtering harmonics from at least one frequency f_{10}, f_{20}, f_{30}, f_{10}', f_{20}', f_{30} derived from the fundamental pulse f_0, 52. The circuit includes switchable splitters 28, 34 controlled by the microprocessor 50 and having sub-splitters (76, 78, 80, 82 Fig 2) and switching means (74, 80, 82, 92). The splitter 34 has shift elements (88, 90).

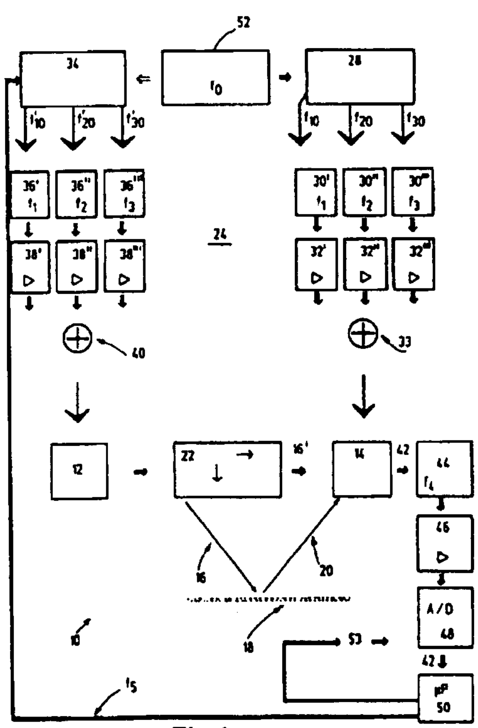

Fig. 1

GB 2 336 493 A

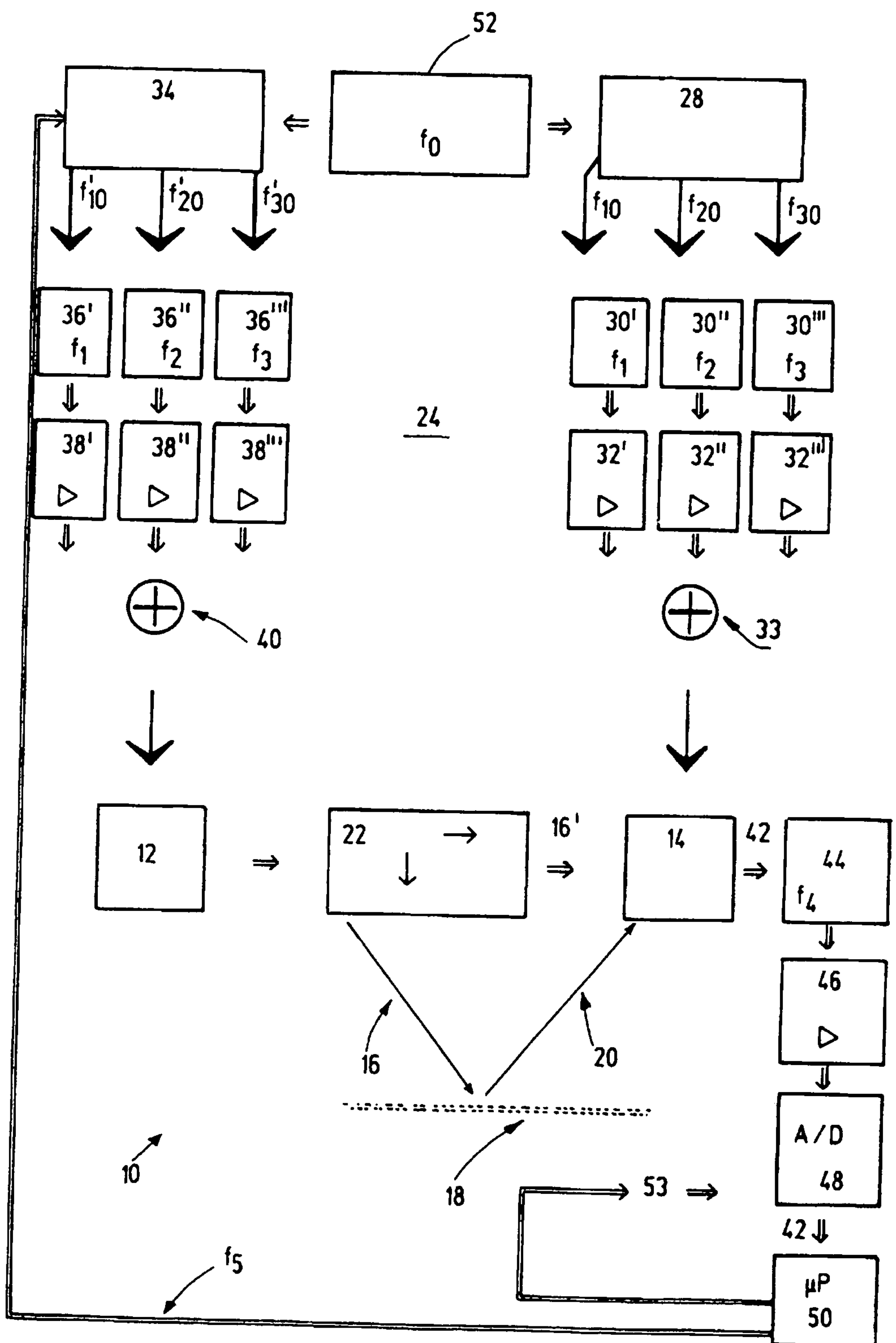
52
34
f_0
28
f'_{10}
f'_{20}
f'_{30}
f_{10}
f_{20}
f_{30}
36'
f_1
36''
f_2
36'''
f_3
30'
f_1
30''
f_2
30'''
f_3
24
38'
38''
38'''
32'
32''
32'''
40
33
12
22
16'
14
42
44
f_4
46
16
20
A / D
48
18
10
53
42
μP
50
f_5

Fig. 1

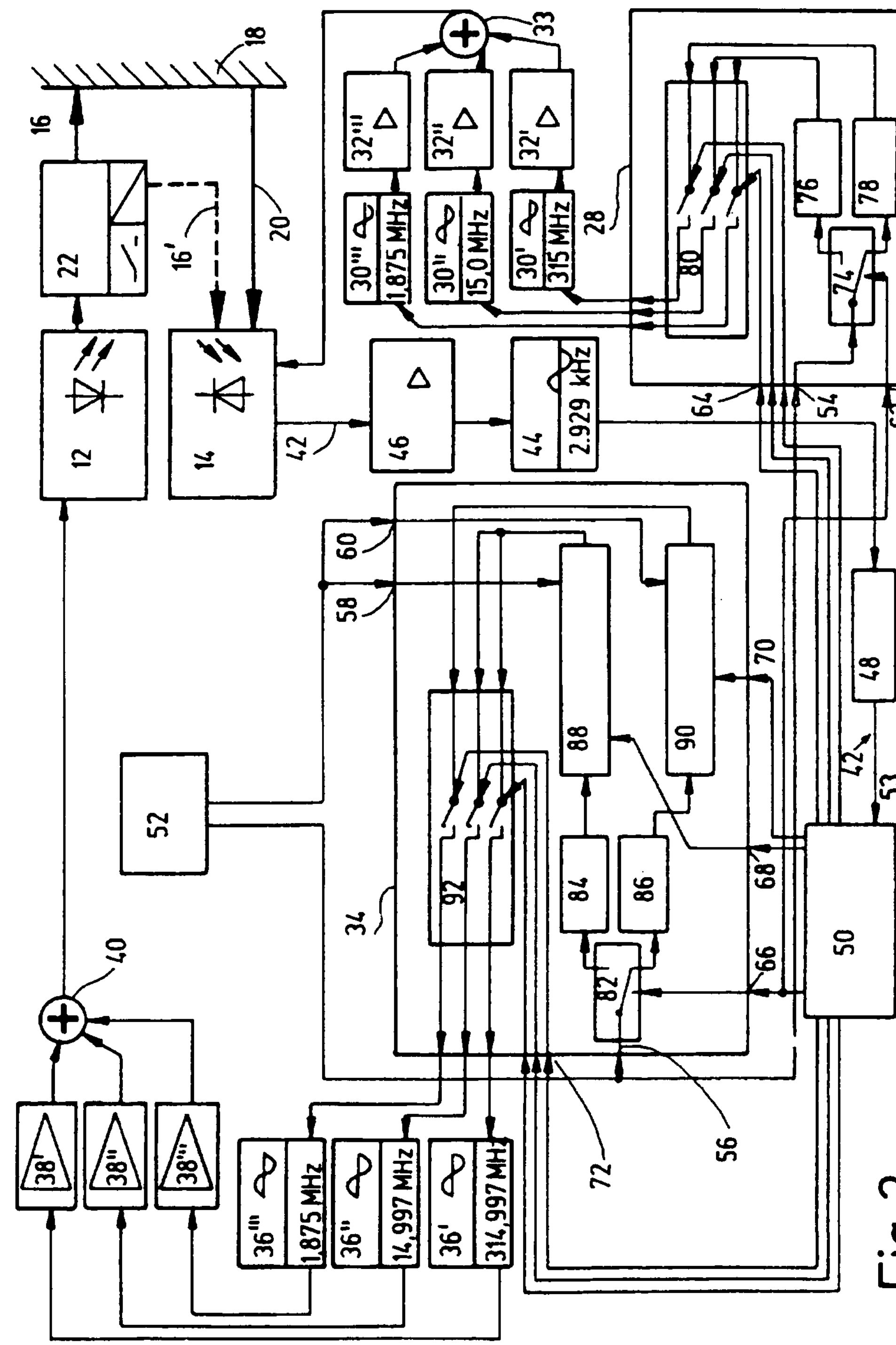
12
14
16
16'
18
20
22
28
30''' 1,875 MHz
30'' 15,0 MHz
30' 315 MHz
32'''
32''
32'
33
34
36''' 1,875 MHz
36'' 14,997 MHz
36' 314,997 MHz
38'
38''
38'''
40
42
44 2.929 kHz
46
48
50
52
53
54
56
58
60
62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92

Fig. 2

2336493

Circuit arrangement for producing frequency signals

The present invention relates to a circuit arrangement for producing at least two signals of different frequency.

Prior art

Generic circuit arrangements are used for example in devices for measuring the distance of an object by means of a collimated laser beam. Such measuring instruments operate inter alia according to a phase difference method, a phase angle between an emitted light beam and a received light beam reflected by an object being evaluated in order to determine the distance between the measuring instrument and the said object. The phase angle is proportional to the distance of the object from the measuring instrument. In order to achieve a high measurement accuracy, it is known to select the measurement frequencies to be as large as possible. Since however unambiguous measurements can be obtained only for a phase angle between 0° and 360°, it is known from DE 43 03 804 A1 to alternate a high modulation frequency of the emitted light beam with at least one further, substantially lower modulation frequency of the emitted light beam in order thereby to achieve a measurement range over the phase angle range from 0° to 360° of the high modulation frequency.

It is also known, in order to achieve a phase difference between the emitted and the received signals, to transform the latter to a lower frequency by mixing, the basic information, namely the phase shift between the emitted and received signals, being maintained. In order to achieve this mixing of a measurement frequency, it is known to mix the emitted and/or received signals with a signal whose

frequency is shifted so slightly that the resulting mixed signal lies in the low frequency range, where the phase can be measured without any problem. In order to generate the different frequency signals required for this purpose, the known circuit arrangements include a corresponding number of frequency oscillators. The associated circuitry and control devices are relatively complicated, and even the slightest calibration error between the individual oscillators can lead to variations in the signal and thus in the end result.

Advantages of the invention

The circuit arrangement according to the invention having the features disclosed in claim 1 provides the advantage that different frequencies can be generated in a simple manner with a high degree of accuracy. Since various frequencies can be derived digitally from an individual frequency oscillator (basic pulse oscillator), all these frequencies have the same relative accuracy as the basic pulse oscillator. The circuit arrangement according to the invention advantageously generates harmonics. Further, very high frequencies having the same stability as the basic pulse oscillator are formed therefrom using narrow-band filters, for example a surface wave filter, frequencies above 100 MHz thereby being possible. A further advantage is that if two of the frequencies derived from the basic pulse oscillator are mixed together, then the low-frequency mixed product is just as stable as the basic pulse oscillator, and moreover without any post-regulation at all. Since all required frequencies are derived simply from a basic pulse oscillator, a frequency error between the individual signals of different frequencies is excluded since these all originate jointly from a fundamental frequency of an oscillator. This is made possible by the fact that the different frequencies are generated purely digitally by synthetic frequency shifting and/or splitting.

The generated harmonics are likewise synthetically, i.e. purely digitally shifted, with the result that they have the same accuracy as the basic pulse oscillator. Even the slightest frequency differences between the individual frequency signals as a result of different origins (several oscillators), leading to variations, are thus reliably avoided. The measuring procedure is accordingly simpler and more accurate. Pairs of frequencies having very close frequencies can thus be produced, very close in this context denoting a frequency difference that cannot be produced from an output frequency by splitting.

Further advantageous modifications of the invention are provided by the remaining features, disclosed in the subclaims.

Drawings

The invention is described in more detail hereinafter by means of an embodiment and with the aid of the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a laser-operated distance measuring instrument, and

Fig. 2 is a block circuit diagram of a laser-operated distance measuring instrument.

Description of the embodiment

Every signal S that is not permanently locked onto a d.c. value is identified hereinafter by the frequency f. The signal S can be sinusoidal, square-wave, or for a limited time sinusoidal and/or square-wave. If the signal S is square-wave, then in addition to the fundamental frequency f further frequencies, so-called harmonics, are also formed. The theory associated with this is known from mathematics and will not be described in more detail here.

If the signal is sinusoidal and/or square-wave only for a limited time, as is the case inter alia with signals that are phase shifted in a regular time sequence by a constant phase angle, then the signal is also termed a frequency. The numerical value f in this case denotes that frequency in the frequency spectrum that occurs with the largest amplitude. In this case frequencies may arise that are not a multiple of the frequency f. Such frequencies are hereinafter also termed harmonics.

Fig. 1 is a diagram of a distance measuring instrument identified overall by the reference numeral 10. The instrument comprises a light emitter 12, for example a laser diode, as well as a light receiver 14, for example a photodiode. A collimated, visible continuous laser beam that is visible at an object 18 (hereinafter also called target) is generated as an emitted signal 16 by means of the light emitter 12. The emitted signal is reflected by the object 18 according to the laws of optics and is received as a received signal 20 by the light receiver 14. The emitted signal 16 is passed as a reference signal 16' to the light receiver 14 immediately after the target measurement, via an optical reversing switch 22, for example a movable shutter.

A circuit arrangement 24 is provided to control the distance measuring instrument 10. This arrangement includes a quartz oscillator 52. The quartz oscillator 52 generates a fundamental frequency f_0 (fundamental pulse 52, Fig. 2), from which are derived all the frequencies, described in more detail hereinafter, involved in the operation of the distance measuring instrument 10. In order to improve the certainty range of the distance measurement using the distance measuring instrument 10, the latter is operated with a total of three modulation frequencies for the emitted signal 16. The emitted signal 16 itself is amplitude-modulated in a manner known per se. The received

signal is consequently also amplitude-modulated in the same way. Since the optical reversing switch is switched over at a known point in time, then on the basis of the time sequence it can be unambiguously established whether the instantaneous optical received signal comes directly from the optical reversing switch or from the target. The light receiver 14 is designed as an avalanche photodiode known per se, and permits several frequencies to be mixed simultaneously. The design, construction and mode of operation of such an avalanche photodiode are known, and accordingly will not be described in more detail within the scope of the present description.

A first switchable splitter 28 is associated with the quartz oscillator 52, by means of which splitter the frequency f_0 generated by the quartz oscillator 52 can be split further as desired into a frequency f_{10}, a frequency f_{20} as well as a frequency f_{30}. The frequencies f_{10}, f_{20}, f_{30} can adopt each value achievable by splitting. Also, at least two of the frequencies may be identical. This is useful for example if harmonics of at least one of the frequencies f_{10}, f_{20}, or f_{30} are filtered out in the connected band-pass filters 32', 32'' and 32'''. Filters 30, designed as band-pass filters 30' for the frequency f_1, 30'' for the frequency f_2 and 30''' for the frequency f_3, are connected to the splitter 28. The following relationship applies as regards the frequencies f_{10}, f_{20}, f_{30}, f_1, f_2, and f_3:

$$f_1 = k' * f_{10}$$
$$f_2 = k'' * f_{20}$$
$$f_3 = k''' * f_{30}$$

k', k'', k''' e 1....N; (N is an arbitrary large number).

Amplifiers 32 are connected to the filters 30, an amplifier 32' being designed for signals of frequency f_1, an amplifier

32'' for signals of frequency f_2, and an amplifier 32''' for signals of frequency f_3. The amplified signals of frequency f_1, f_2 and f_3 are passed through a summing element 33 to the light receiver 14.

A second switchable splitter with an additional digital circuit arrangement 34 is associated with the quartz oscillator 52. Signals of frequencies f_{10}', f_{20}' and f_{30}' can be fed to the output of the splitter 34. The frequencies f_{10}', f_{20}' and f_{30}' are reswitched as regards their phase with a frequency f_5 by means of the digital circuit arrangement 34. A mixture of several frequency lines is produced in this way in the frequency spectrum. At least two of the frequencies f_{10}', f_{20}' and f_{30}' may be identical. This is useful for example if harmonics from at least one of the frequencies f_{10}', f_{20}' or f_{30}' are filtered out in the connected band-pass filters 36', 36'' and 36'''. Band-pass filters 36 are associated with the splitter 34, a filter 36' being designed for signals of frequency f_1', a filter 36'' for signals of frequency f_2', and a filter 36''' for signals of frequency f_3'.

Amplifiers 38 are connected to the filters 36, an amplifier 38' being designed for signals of frequency f_1', an amplifier 38'' for signals of frequency f_2', and an amplifier 38''' for signals of frequency f_3'. The amplified signals of frequencies f_1', f_2' and f_3 are passed through a summing element 33 to the light emitter 12. The emitted signal 16 is modulated by means of the light emitter 12 according to the switched-through frequency f_1', f_2''' and f_3'''.

The light receiver 14 receives a time-spaced succession of optical signals denoted hereinafter by A, and with each optical signal simultaneously receives the electrical signal denoted hereinafter by B:

List A of optical signals	List B of associated electrical signals
- target signal 20 of frequency f_1'.....	Mixed signal of frequency f_1
- target signal 20 of frequency f_2'.....	Mixed signal of frequency f_2
- target signal 20 of frequency f_3'.....	Mixed signal of frequency f_3
- reference signal 16' of frequency f_1'.....	Mixed signal of frequency f_1
- reference signal 16' of frequency f_2'....	Mixed signal of frequency f_2
- reference signal 16' of frequency f_3'.....	Mixed signal of frequency f_3

A transformation by mixing to produce an evaluation signal 42 is achieved hereby. This evaluation signal 42 contains the required basic information, namely the phase angle of the target signal 20 in relation to a A/D transducer pulse 53 on the one hand and, in time succession, the phase angle of the reference signal 16' in relation to the A/D transducer pulse on the other hand. The reference quantity is derived from the difference in the two phase angles per measurement frequency, since it remains unaltered in all subsequent measurements. The result is a phase angle per measurement frequency pair $f_1'-f_1$, $f_2'-f_2$ and $f_3'-f_3$, i.e. a total of three phase angles. The smallest frequency of the frequencies f_1', f_2' and f_3' determines the certainty range of the overall distance measurement. The largest frequency of the frequencies f_1', f_2' and f_3' determines the maximum possible measurement accuracy for a given measurement time. The frequency from f_1', f_2' and f_3' lying between the largest and smallest frequencies is in principle not necessary. It is however advantageously used if the measurement accuracy of the smallest frequency is not sufficient to allocate the measurement result of the

largest frequency to the correct range in each case. This is necessary in order to be able to measure distances that are greater than the certainty range of the highest frequency.

The frequency f_3 is chosen to be relatively small in order to use a slow A/D transducer having a high resolution. The evaluation signal 42 is fed through an anti-aliasing filter 44, which forms a band-pass filter for the evaluation signal of frequency f_4, and from there is led through an amplifier 46 to an analog-digital transducer 48. The converted evaluation signal 42 is passed to a microprocessor 50 that includes the appropriate computing, storage, counting facilities, etc., for determining the distance of the object 18 from the distance measuring instrument 10. The transducer pulse 53 for controlling the analog-digital transducer 48 is generated at the same time via the microprocessor 50. In addition a frequency signal f_5 (trigger signal) of the microprocessor 50 that is in an at least timewise fixed relationship to the transducer pulse 53 is utilised to shift the frequencies f_{10}, f_{20} and f_{30} to the frequencies f_{10}', f_{20}' and f_{30}'.

The generation of the frequencies f_{10}, f_{20}, f_{30}, f_{10}', f_{20}', as well as f_{30}' is explained in more detail hereinafter with the aid of Fig. 2, which in the form of a block circuit diagram of the measuring instrument 10 shows in particular the circuit arrangement 24. Parts that are identical to those in Fig. 1 are given the same reference numerals and will not be described again.

The shift of the frequencies f_1, f_2 and f_3 by the frequency f_4 to the frequencies f_1', f_2' as well as f_3', and the generation of the frequencies f_1, f_2, f_3, f_1', f_2' as well as f_3' from the frequencies f_{10}, f_{20}, f_{30}, f_{10}', f_{20}' as well as f_{30}', are illustrated in particular on the basis of Fig. 2. In the embodiment it is assumed that the frequency f_{10} is

15 MHz, the frequency f_{20} is 15 MHz, the frequency f_{30} is 1,875 MHz, the frequency f_1 is 315 MHz, the frequency f_2 is 50 MHz, and the frequency f_3 is 1.875 MHz.

The frequency f_4 by which the frequencies f_1, f_2 and f_3 are shifted is 2.929 kHz, so that the frequency f_1' is 314.997 MHz, the frequency f_2' is 14.997 MHz and the frequency f_2' (sic) is 1.872 MHz. All frequencies are digitally generated by means of the trigger signal of frequency f_5 from the microprocessor 50. In the example it is assumed that the trigger signal f_5 at the frequency f_1 of 315 MHz and at the frequency f_2 of 15 MHz is exactly four times the frequency of f_4. At the frequency f_3 of 1.875 MHz the trigger signal f_5 is 32 times the frequency of f_4. In the example the quartz oscillator 52 has the frequency f_0 = 60 MHz. Obviously other frequencies are also possible according to further embodiments.

The microprocessor is pulsed by a separate frequency oscillator whose function is however subordinate and is therefore not shown. The processor pulse may advantageously also be generated by splitting f_0.

The fundamental pulse 52 is fed to an input 54 of the splitter 58, and to an input 56 as well as inputs 58 and 60 of the splitter 34. In addition the microprocessor 50 is connected to inputs 62 as well as 64 (triple input) of the splitter 28, and to inputs 66, 6 and 70 as well as 72 (triple input) of the splitter 34.

The splitter 28 has a switching means 74 whose input is connected to the input 54 and whose switching outputs are connected to a splitter 76 and to a splitter 78. The splitters 76 and 78 are connected to a switching means 80, designed as a triple on-off switch. The three switching outputs of the switching means 80 are each connected to one of the filters 30', 30'' and 30''', while the splitter 78

is connected to one switching input and the splitter 76 to two switching inputs of the switching means 80.

The switching means 74 and 80 are controlled via switching signals generated by the microprocessor 50 at the inputs 62 and 64 respectively, the switching means 74 being able to be switched over to one of its two switching positions, and the switching means 80 being able to be switched on with one of its three switching elements. The splitter 76 splits the frequency f_0, of the fundamental pulse 52 fed through the input 54, by a factor of thirty two, and the splitter 78 splits the frequency f_0 of the fundamental pulse 52 by a factor of four, with the result that the corresponding frequencies f_1, f_2, and f_3 are filtered out by the filters 30', 30'' and 30''' respectively. The frequencies f_1, f_2 and f_3 may be harmonics of the signals f_{10}, f_{20} and f_{30} at the outputs of the switching means 80.

The components 74, 76, 78 and 80 identified by the reference numeral 28 may advantageously be replaced by an integrated logic circuit. The switching and splitting functions are in this case performed by flip-flops, AND gates, OR gates, EXCLUSIVE-OR gates, and further logic elements.

The splitter 34 has a switching means 82 that is connected to the input 56. The switching outputs of the switching means 82 are connected to a splitter 84 and a splitter 86. The output of the splitter 84 is connected to a shift element 88 and the output of the splitter 86 is connected to a shift element 90. The splitter 34 also includes a switching means 93 (triple on-off switch), whose switching outputs are connected to the filters 36', 36'' and 36'''. The shift element 90 is connected to a switching input, and the switching element 88 is connected to two switching inputs of the switching means 92. The switching elements of the switching means 82 and 92 can be controlled via the

microprocessor 50, the switching means 82 connecting the input 56 as desired to either the splitter 84 or splitter 86. The splitter 84 has a splitting factor of four, and the splitter 89 a splitting factor of thirty two, by means of which the frequency of the fundamental pulse 52 present at the input 56 can be split.

The shift elements 88 and 90 are connected via the inputs 58 and 60 to the fundamental pulse 52. The shift elements 88 and 90 are also connected via the inputs 66 and 70 to the trigger signal f_5 (see Fig. 1) of the microprocessor. Corresponding to this trigger signal, the frequencies split via the splitters 84 and 86 at the input of the shift elements 88 and 90 respectively are shifted by exactly one fundamental pulse. This phase shift occurs at 2.929 kHz in the frequency range in the example in which the fundamental pulse f_0 = 60 MHz. The frequencies f_{10}', f_{20}' and f_{30}' are thus digitally generated by means of the shift elements 88 and 90. The frequencies f_1', f_2' and f_3' are formed by filtering out the corresponding harmonics.

The components 82, 84, 86, 88, 90 and 92 identified by the reference numeral 34 may advantageously be replaced by an integrated logic circuit. The switching and splitting functions are in this case performed by flip-flops, AND gates, OR gates, EXCLUSIVE-OR gates, and further logic elements.

A phase difference measurement was used for illustrative purposes in the described embodiment. Other phase measurement methods, for example a null passage measurement, are obviously also possible.

Patent claims

1. Circuit arrangement for generating at least two signals of different frequencies, characterised in that at least one pair of frequencies having closely adjacent frequencies (f_1 and f_1', f_2 and f_2', f_3 and f_3') are derived from a frequency oscillator (fundamental pulse f_0).

2. Circuit arrangement according to claim 1, characterised in that a trigger signal (f_5, 68) is used to generate different, closely adjacent frequencies (f_1 and f_1', f_2 and f_2', f_3 and f_3').

3. Circuit arrangement according to one of the preceding claims, characterised in that at least one of the signals (f_1', f_2', f_3') is shifted by means of the trigger signal (f_5) by a constant time interval predetermined by a fundamental pulse (f_0).

4. Circuit arrangement according to one of the preceding claims, characterised in that the trigger signal (f_5) for generating at least two different frequencies (f_1 and f_1', f_2 and f_2', and f_3 and f_3') is generated by an oscillator of lesser accuracy.

5. Circuit arrangement according to one of the preceding claims, characterised in that at least one frequency (f_1, f_2, f_3, f_1', f_2', f_3') is generated by filtering out harmonics from at least one frequency (f_{10}, f_{20}, f_{30}, f_{10}', f_{20}', f_{30}') derived from the fundamental pulse (f_0, 52).

6. Circuit arrangement according to one of the preceding claims, characterised in that all frequencies (f_1, f_2, f_3)

are in each case shifted by exactly one frequency (f_4) from the associated frequencies (f_1', f_2', f_3').

7. Circuit arrangement according to one of the preceding claims, characterised in that the circuit arrangement includes switchable splitters (28, 34) that can be controlled by means of a microprocessor (50).

8. Circuit arrangement according to one of the preceding claims, characterised in that the splitter (28) is designed to generate at least one frequency (f_{10}, f_{20}, f_{30}) and the splitter (34) is designed to generate at least one shifted frequency (f_{10}', f_{20}', f_{30}').

9. Circuit arrangement according to one of the preceding claims, characterised in that the splitters (28, 34) have sub-splitters (76, 78, 80, 82) for generating multiple frequencies (f_{10}, f_{20}, f_{30} and f_{10}', f_{20}', f_{30}').

10. Circuit arrangement according to one of the preceding claims, characterised in that the splitters (28, 34) for generating as desired one of the frequencies (f_{10}, f_{20}, f_{30} and f_{10}', f_{20}', f_{30}') have switching means (74, 80, 82, 92).

11. Circuit arrangement according to one of the preceding claims, characterised in that the splitter (34) has shift elements (88, 90) for shifting by the frequency (f_4), which elements can be controlled via a trigger signal from the microprocessor (50) and permit a shift of an input frequency by at least one fundamental pulse (f_0).

12. Circuit arrangement according to one of the preceding claims, characterised in that filters (30, 36) for the band-pass filtering of signals with frequencies (f_{10}, f_{20}, f_{30}, and f_{10}', f_{20}', f_{30}') are connected to the splitters (28, 34).

13. Circuit arrangement according to one of the preceding claims, characterised in that harmonics are filtered out from at least one of the generated frequencies (f_{10}, f_{20}, f_{30}, f_{10}', f_{20}', f_{30}') by means of SAW filters (= surface wave filters).

14. Circuit arrangement according to one of the preceding claims, characterised in that the splitter (34) comprising the components (82, 84, 86, 88, 90 and 92) is realised by means of an integrated logic circuit.

15. Circuit arrangement according to one of the preceding claims, characterised in that the splitter (28) comprising the components (74, 76, 78 and 80) is realised by means of an integrated logic circuit.

16. Circuit arrangement according to one of the preceding claims, characterised in that the circuit arrangement (24) is used to generate modulation frequencies of laser signals (16) from a distance measuring instrument (10).

17. Circuit arrangement substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

15

INVESTOR IN PEOPLE

Application No: GB 9904155.0
Claims searched: 1-17
Examiner: Brian Ede
Date of search: 14 July 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3R(RMA)

Int Cl (Ed.6): H03B 21/02

Other: Online: EPODOC; JAPIO; WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2128048 A	(RACAL-DANA) see The Fig	1 at least
X	GB 2039441 A	(TELEFONGYAR) The Fig	1 at least
X	GB 1420271	(SOC D'ETUDE ET D'APPLICATION DES TECHNIQUES NOUVELLLES) see Fig 1	1 at least
X	GB 1348221	(MARCONI) see The Fig	1 at least
X	GB 1264770	(STC) see The Fig	1 at least
X	US 5107124	(SIEMENS) see CL, BG1, BG2 Fig 1	1 at least
X	US 4959654	(HONEYWELL) see 52, 501, 502 Fig 3	1 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.